

SPECTROMETER

a We claim
CLAIMS

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1. An apparatus for measuring spectral information of light from at least one object (15); said apparatus comprising

10 at least one light detecting means (34); and

at least one transparent body (31) having a front side (F) and a back side (B);

15 said front side including:

an entrance surface (311) having positioned in or near thereof at least one entrance aperture means (30) for receiving light from the at least one object, and

20 at least one reflecting surface (312); and

said back side including:

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at least one other reflecting surface (313) for reflecting light received from said at least one entrance aperture means to said at least one reflecting surface of the front side, and

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an exit surface (314); said exit surface being arranged in a mutual relationship with said at least one light detecting means (34); said detecting means being positioned in or near thereof, or positioned at a distance therefrom, for detecting the reflected

light from said at least one reflecting surface of the front side;

5 said at least one other reflecting surface of the back side, said at least one reflecting surface of the front side, or both, having at least one diffractive optical element (32) and/or at least one focusing means (33);

10 said at least one diffractive element and said at least one focusing means being arranged so that the transmitted light is diffracted before being focused; and

15 said at least one transparent body being transparent to the lights from the object, said other reflecting surface of the back side, and said reflecting surface of the front side.

2. The apparatus according to claim 1 wherein the apparatus further comprises aberration correcting means.

20 3. The apparatus according to claim 2 wherein the aberration correcting means is selected from the group consisting of an aspheric focusing means, a tilted exit surface, an aspheric exit surface, and a combination thereof.

25 4. The apparatus according to any one of claims 1-3 wherein the front side includes:

30 at least one further reflecting surface (312b); and

the said back side includes:

35 at least one further reflecting surface (313b);

said further reflecting surfaces being arranged to reflect light more times before being received by the at least one focusing means (33), the at least one diffractive means (32), or both.

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5. The apparatus according to any one of claims 1-4 wherein the at least one diffractive optical element (32), the at least one focusing means (33), the reflecting surfaces (312b, 313b) or all, are positioned above and/or below the respective surfaces of the front side and back sides of the at least one transparent body.

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6. The apparatus according to any one of claims 1-5 wherein the at least one diffractive optical element (32) and the detection means (34) are arranged in parallel planes or coinciding planes.

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7. The apparatus according to any one of claims 1-6 wherein the entrance surface (311a) and the exit surface (314a) are parallel.

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8. The apparatus according to any one of claims 1-7 wherein the entrance aperture means consists of a rectangular slit.

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9. The apparatus according to any one of claims 1-8 wherein the entrance aperture means is constituted by an optical fiber means.

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10. The apparatus according to any one of claims 1-9 wherein the at least one diffractive optical element is aspheric.

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11. The apparatus according to any one of claims 1-10 wherein the focusing means is aspheric.

12. The apparatus according to any one of claims 1-11 wherein the at least one light detecting means is positioned at a distance from the surface of the exit surface of the at least one transparent body.
13. The apparatus according to any one of claims 1-12, wherein the at least one light detecting means is positioned below or above the surface of the exit surface of the at least one transparent body.
14. The apparatus according to any one of claims 1-13 wherein said at least one transparent body is a unitary body (31), or a composed body (31a,31b).
15. The apparatus according to claim 14 wherein said transparent body is a composed body (31a,31b) comprising a front part, a back part, and optionally an intermediate part; said front part incorporating said entrance aperture means (30), said at least one diffractive optical element (32) and/or said at least one focusing means (33); and said back part incorporating said exit face, said at least one diffractive optical element (32) and/or said at least one focusing means (33).
16. The apparatus according to claim 15 wherein said optionally intermediate part consists of a material selected from the group consisting of a low cost transparent material, a thermally stable transparent material, and a filtering material, or a combination thereof.
17. The apparatus according to claims 14-16, wherein said unitary or composed body is fabricated by means of replication.

18. The apparatus according to any one of claims 1-17 wherein said at least one transparent body is covered by light absorbing material.

5 19. The apparatus according to claim 18 wherein said light absorbing material has a refractive index identical to the refractive index of said at least one transparent body.

10 20. The apparatus according to any one of claims 18 or 19 wherein said light absorbing material is coated onto said at least one transparent body.

15 21. The apparatus according to any one of claims 1-20 wherein said light absorbing material is molded into said at least one transparent body.

20 22. The apparatus according to any one of claims 1-20 wherein said light absorbing material (315) is positioned inside said at least one transparent body.

23. The apparatus according to any one of claims 1-22 comprising at least two spectrometer channels (41a, 41b).

25 24. The apparatus according to claim 23 wherein said the at least two spectrometer channels are parallel.

30 25. The apparatus according to claim 23 wherein said at least two spectrometer channels are placed in continuation of each other.

26. The apparatus according to any one of claims 1-25 further comprising at least one reference light source (38) for illumination of the object (15) to be measured.

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27. The apparatus according to claim 26 wherein said at least one reference light source (38) illuminates the object (15) in a reflection configuration.

5 28. The apparatus according to claim 26 wherein said at least one reference light source (38) illuminates the object (15) in a transmission configuration.

10 29. The apparatus according to any one of claims 1-28 wherein said body comprises at least one measuring part (41a) for measuring light from the object and a reference part (41b) for measuring light from the at least one reference light source.

15 30. The apparatus according to claim 29 wherein said part of the reference light (38) is guided to said reference channel (41b) by a guiding plate (61).

20 31. The apparatus according to claim 29 wherein said part of the reference light (38) is guided to said reference channel (41b) by optical fiber means.

25 32. The apparatus according to any of claims 29-31 further comprising means for removing spectral influence of the reference light in the measured light from the at least one object which means communicates with light detection means for the at least one measuring part and with light detection means for the reference part of said body.

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33. The apparatus according to any one of claims 1-32 further comprising a light spot source (51) for illuminating a light spot (53) onto the object; and a distance sensing means for measuring the distance between the object and said entrance aperture means.

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34. The apparatus according to claim 33 wherein the light spot source is a monochromatic light source, preferably a laser or a LED with limited bandwidth.

5 35. The apparatus according to any one of claims 33-34 wherein said distance sensing means includes means (52) for focusing a light spot (53) from the object onto the spot detection means (44c).

10 36. The apparatus according to claim 35 wherein the focusing means (52) comprises a wavelength bandpass filter (63) allowing only passage of light within the bandwidth of the light spot source (51).

15 37. The apparatus according to any one of claims 33-36 wherein said distance sensing means further include means for determining the spot size on said spot detection means, and/or means for determining the position of the imaged spot on said spot detection means (44c).

20 38. The apparatus according to any one of claims 33-37 wherein the said spot detection means (44c) is a position sensitive detector or an array detector.

25 39. The apparatus according to any one of claims 33-38 wherein said distance sensing means further include distance converting means for converting either the spot size or the spot position on the spot detection means to a distance to the object, preferably by geometrical magnification or by triangulation.

30 40. The apparatus according to any one of claims 33-39 further comprising means for removing the influence of the varying object distance in the measured light from the object.

41. An apparatus for measuring spectral information of light from at least one object (15); said apparatus comprising

5 at least one light detecting means (34); and

at least one transparent body (31) including:

10 an entrance surface (311) having positioned in or near thereof at least one entrance aperture means (30) for receiving light from the at least one object, and

15 one or more reflecting surfaces (312,313); and

20 an exit surface (314); said exit surface being arranged in a mutual relationship with said at least one light detecting means (34) positioned in or near thereof, or positioned at a distance therefrom, for detecting the reflected light from said one or more reflecting surfaces;

25 said one or more reflecting surfaces having at least one diffractive optical element (32) and/or at least one focusing means (33);

30 said at least one focusing means being arranged so that the transmitted light is diffracted before being focused;

35 said at least one transparent body being transparent to the lights from the object and said one or more reflecting surfaces, and

40 said at least one transparent body being composed of several parts for measuring light from several objects.

42. The apparatus as claimed in claim 41 wherein the several parts for measuring light from several objects comprise at least one measuring part (41a) for measuring 5 light from one or more objects and a reference part (41b) for measuring light from a reference light source.

43. An apparatus for measuring spectral information of light from at least one object (15); said apparatus 10 comprising

at least one light detecting means (34);

15 at least one light spot source (51) for illuminating a light spot onto the at least one object; and

at least one transparent body (31); said body including:

20 an entrance surface (311) having positioned in or near thereof at least one entrance aperture means (30) for receiving light from the object, and

one or more reflecting surfaces (312,313); and

25 an exit surface (314); said exit surface being arranged in a mutual relation ship with said at least one light detecting means (34); said detecting means being positioned in or near thereof, or positioned at a distance therefrom, for detecting the reflected 30 light from said one or more reflecting surfaces; and

distance sensing means for measuring the distance between the at least one object and said entrance aperture means;

said one or more reflecting surfaces having at least one diffractive optical element (32) and/or at least one focusing means (33);

5 said at least one focusing means being arranged so that the transmitted light is diffracted before being focused; and

10 said at least one transparent body being transparent to the lights from the object and said one or more reflecting surfaces.

15 44. An apparatus for measuring spectral information of light from at least one object (15); said apparatus comprising

at least one light detecting means (34);

20 at least one light spot source (51) for illuminating a light spot onto the at least one object;

at least one transparent body (31) including:

25 an entrance surface (311) having positioned in or near thereof at least one entrance aperture means (30) for receiving light from the at least one object, and

30 one or more reflecting surfaces (312, 313); and

35 an exit surface (314); said exit surface being arranged in a mutual relationship with said at least one light detecting means (34) positioned in or near thereof, or positioned at a distance therefrom, for detecting the reflected light from said one or more reflecting surfaces;

said one or more reflecting surfaces having at least one diffractive optical element (32) and/or at least one focusing means (33);

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said at least one focusing means being arranged so that the transmitted light is diffracted before being focused; and

10 distance sensing means for measuring the distance between the at least one object and said entrance aperture means;

15 said at least one transparent body being transparent to the lights from the object and said one or more reflecting surfaces, and

said at least one transparent body being composed of several parts for measuring light from several objects.

20 45. The apparatus as claimed in claim 44 wherein the several parts for measuring light from several objects comprise at least one measuring part (41a) for measuring light from one or more objects and a reference part (41b) for measuring light from a reference light source.

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46. A method of measuring spectral information of light from at least one object (15), said method comprising:

30 measuring light from at least one object by an apparatus comprising light detection means and at least one transparent body as defined in any one of the preceding claims;

said method further comprising:

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illuminating the at least one object by light from at least one reference light source (38);

simultaneously, measuring object light from the
5 illuminated objects in at least one measuring channel (41a) and measuring reference light from the at least one reference light source in at least one reference channel (41b); and

10 removing spectral influence of the reference light in the measured light from the object.

47. A method according to claim 46, wherein the spectral influence of the reference light in the object light is removed by subtracting the measured reference light from the measured object light.

48. A method according to claim 46, wherein the spectral influence of the reference light in the object light is removed by correcting for changes in the reference light compared to a reference measurement taken at a first calibration.

49. A method according to any one of claims 46-48,
25 further comprising the steps of:

illuminating light from a light spot source onto the object;

30 focusing light from the light spot on the object (53) onto the spot detection means (44c); and

determining the spot size or the spot position on said spot detection means; and

determining the distance to the object, preferably by geometrical magnification or by triangulation.

50. A method of measuring spectral information of light
5 from at least one object (15), said method comprising:

measuring light from at least one object by an apparatus
comprising light detection means and at least one
transparent body as defined in any one of the preceding
10 claims;

said method further comprising:

correcting the influence of distance between the objects
15 and the apparatus on the measure object light;

said correction comprising measuring said distance by:

illuminating light from a light spot source onto the
20 object;

focusing light from the light spot on the object onto the
spot detection means (44c);

25 determining the spot size or the spot position on said
spot detection means; and

determining the distance to the object, preferably by
geometrical magnification or by triangulation.

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